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Inadequacies in Soviet Wheat Varieties and Breeding Research

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Inadequacies in Soviet Wheat Varieties and Breeding Research

Project Officer

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PRÉCIS

Wheat variety inadequacies are reducing the yields which the Soviets might expect to achieve through greater use of fertilizer, mechanization, drainage and irrigation, pest control, and other cultivation practices. The Soviet failure to develop and introduce new and improved wheat varieties is one of the reasons for the shortage of total grains available for feeding farm animals—the principal means for stimulating output of meat, milk and eggs. Moreover, the shortage of top quality wheat increases the difficulty of making good quality bread—still a mainstay in the Soviet diet.

Despite a large program of wheat breeding research the Soviets have developed no really new varieties in almost two decades, primarily because they gambled on simplistic shortcuts rather than on more careful research into basic problems. Practically all Soviet wheats are susceptible to new races of leaf rust fungus, relatively few are resistant to insect pests, and all are susceptible to structural weaknesses. Varieties which in previous years permitted large increases in yields are now reaching the limit of their potential. Even if proper wheat breeding research were initiated now, no major improvement in the Soviet commercial inventory of wheat varieties could occur for several years and possibly even for a decade or more.

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INADEQUACIES IN SOVIET WHEAT VARIETIES AND BREEDING RESEARCH

Project Officer

OSI-STIR/75-27
November 1975

CENTRAL INTELLIGENCE AGENCY
DIRECTORATE OF SCIENCE AND TECHNOLOGY
OFFICE OF SCIENTIFIC INTELLIGENCE

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PREFACE

One of the major agricultural problems in the USSR is the quantity production of good quality wheat. The prime purpose of growing wheat is to supply the indigenous requirements for food grains both for immediate uses and strategic reserves. Bread is still a mainstay in the Soviet diet, and wheat is the principal grain exported, largely to fulfill Soviet commitments to supply food grain needs of client states. In recent years relatively large quantities of wheat also have been used to feed livestock.

This report reviews Soviet progress in developing new varieties of wheat and assesses its likely impact on future production of grain. It was prepared by the Office of Scientific Intelligence and coordinated within CIA. The report contains information available through August 1975.

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CONTENTS

APPENDICES

TABLES

FIGURES

INADEQUACIES IN SOVIET WHEAT VARIETIES AND BREEDING RESEARCH

PROBLEM

To evaluate Soviet commercial wheat varieties and wheat breeding research and to determine their impact on grain production in the USSR.

SUMMARY AND CONCLUSIONS

The USSR produces over one-fourth of the world's wheat—twice the US output. Yet there is a shortage of high quality wheat needed to satisfy the increasingly sophisticated requirements of the Soviet bread-making industry. A prime factor contributing to the shortage is the Soviet failure to develop and introduce new and improved wheat varieties. This failure also has slowed the rate of yield increases, thus limiting Soviet ability to provide the increasing amount of grain needed for livestock, a key factor in attempts to fulfill Brezhnev's pledge to provide consumers with more meat, milk and eggs. These same deficiencies in varieties of wheat also are contributing to the wide fluctuations in Soviet grain yields which then cause major disturbances in world grain markets.

Despite their broad program of wheat breeding research, the Soviets have developed no really new varieties in the past two decades, primarily because they gambled on simplistic shortcuts rather than on more careful research into basic problems. Even if proper wheat breeding research were initiated now, no major improvement in the Soviet commercial inventory of wheat varieties could occur for several years and possibly even for a decade or more because of the time required to produce new genetic crosses. The possibilities of obtaining improved strains from the few parent varieties now being emphasized have probably been exhausted. In spite of widespread testing of US and other foreign wheat varieties, none of them has demonstrated a capability to meet the special Soviet growing conditions and requirements, except on an extremely limited scale. Only a few foreign varieties have proven suitable and have been accepted by the Soviets for limited adoption in very specific and narrow climatic and geographic zones. The USSR primarily utilizes foreign varieties as sources of germ plasm for domestically developed varieties.

Paradoxically, certain Soviet wheat varieties have attracted world acclaim. Since 1969 the winter wheat variety Bezostaya-1 has produced the highest yield in the International Wheat Performance Trials. Bezostaya-1 has been grown commercially since 1959 and probably is the most widely grown variety in the world. It monopolizes the southern regions of the European USSR and Eastern European winter wheat belts. Similarly Mironovskaya-808, developed in 1957, dominates the northern portion of the winter wheat acreage in the USSR and Eastern Europe. The spring variety Saratovskaya-29, in commercial use since 1957 and occupying 45 percent of the USSR non-durum spring wheat area, is capable of producing wheat of a quality commensurate with the best in the world. The Kharkovskaya-46 variety accounts for 95 percent of the USSR durum wheat area.

Heavy reliance in the USSR on a few varieties has left the Soviets vulnerable to the shortcomings of those varieties. In particular, most of the Soviet wheats are susceptible to new, virulent races of leaf rust which in 1973 reduced yields in some areas below their potential by 25-50 percent and in 1974 by up to 20 percent. Also relatively few of the commercial varieties are resistant to insect pests. All are susceptible to lodging and to shattering.

In recent years, up to one-third of the area seeded to winter wheat failed to survive the winter. Spring wheat in parts of Siberia and the Urals frequently fails to mature before the onset of killing frosts. Other varietal problems include poor drought resistance and a tendency for the kernels in the unthreshed heads to sprout. The Soviets are concerned with deterioration in protein content and other parameters of wheat quality. These problems are caused largely by variety improvement not keeping pace with changes in cultivation practices. Finally, varietal inadequacy is restricting yield responses that can be expected through higher inputs of fertilizer, mechanization, land melioration, pest controls, and other cultivation practices. The major Soviet wheat varieties and their characteristics are summarized in table 1.

Table 1

Distribution and Suitability of Soviet Commercial Wheat Varieties

Variety	Percent of Total Soviet Wheat*		Remarks
	Area	Production	
Bezostaya-1 (Winter wheat)	13	22	Developed by the Soviets from foreign and domestic germ plasm ranked high in recent international yield trials. It is the predominant variety in the southern half of the Soviet winter wheat belt. Even that far south, because of its relatively low winter hardiness, large losses of sown area occur during unusually severe winters. Also, its relatively high resistance to lodging is insufficient during high rainfall years under the current, higher rates of fertilizer application. Moreover, its concentrated use has led to the buildup of new, virulent strains of leaf rust fungus.
Mironovskaya-808 (Winter wheat)	15	22	Allegedly developed by the Soviets by a controversial procedure of transforming an old Russian spring variety into a winter type; it is the predominant variety in the northern part of the USSR winter wheat belt. Its above-average winter hardiness makes it suitable to this region where its relatively low resistance to lodging and to disease are less serious than they would be in regions farther south.
Saratovskaya 29 (Spring wheat)	30	25	Derived exclusively from crosses of old Russian varieties, it predominates in the prime spring wheat areas. Under select growing conditions it produces grain of very good milling and baking quality but the quality of grain declines as farming practices and overall growing conditions are improved. It has low resistance to leaf rust, its drought resistance is limited, and it lodges severely in high rainfall years.
All Other Varieties (Primarily spring wheat)	42	31	Of a wide assortment of commercial varieties many are adapted only to restricted soil-climate zones and most of those more widely grown are genetically similar to the three varieties above. Like the predominant varieties, practically all are highly susceptible to insect and disease pests, lodging, shattering and premature sprouting. In general, they are insufficiently hardy for conditions in the USSR and lack potential for producing higher yields and good quality wheat under improved cultivation techniques.

*Estimated.

DISCUSSION

INTRODUCTION

Wheat is the most important agricultural crop in the world. The Soviet Union is the world's largest producer of wheat, accounting for 27 percent of the global output.[1] Beginning in the late 1950s, wheat has generally comprised about one-half of total Soviet grain output.[2, 3] Soviet production of wheat has approximately kept pace with the increase in total grain production (table 2). In recent years one-half or more of the Soviet acreage sown to all grains and almost one-third of the acreage sown to all crops have been devoted to wheat.[4] Practically all agricultural areas of the USSR grow some wheat, but natural and climatic advantages have concentrated wheat growing in certain areas more than in others (figure 1). Since much of the country experiences winters too severe for fall-planted winter wheats to survive, two-thirds to three-fourths of all wheat area is devoted to spring wheat which accounts for one-half to two-thirds of total wheat output.

As in the rest of the world, the bulk of Soviet wheat acreage is devoted to common wheat* used for making bread and pastry. The remaining acreage, about 9 percent of all wheat area, is primarily devoted to durum wheat used for macaroni and other pasta products. In terms of their growth habit, both common and durum wheats differentiate into winter and spring types.[5] The main winter wheat growing areas, accounting for two-thirds of the total winter wheat output, are the Ukraine, Moldavia and the northern Caucasus (table 3).[6, 8] In these areas winter wheat comprises about one half of all grains. Only winter type wheat is grown in the Baltics and

*Scientists classify as wheat selected species of the genus Triticum which is a member of the grass family (Graminae). As many as 22 species are classified as wheats, 12 have at some time been cultivated and eight are fairly well known. Only two species, however, are of commercial significance in the USSR: Common wheat (Triticum aestivum or Triticum vulgare) and durum wheat (Triticum durum). The other species, though insignificant in terms of production, are potentially important for breeding cultivated wheats, and as germ plasm for imparting desirable characteristics otherwise not available.

Table 2

USSR: Production of Wheat and All Grains

Year(s)	Million Tons		Index, 1961–65 = 100	
	Wheat	All Grains	Wheat	All Grains
1951-55 avg	41.5	88.5	65	68
1956-60 avg	67.1	121.5	105	93
1961-65 avg	64.2	130.3	100	100
1966-70 avg	90.2	167.6	141	129
1970	99.7	186.8	155	143
1971	98.8	181.2	154	139
1972	86.0	168.2	134	129
1973	109.7	222.5	171	171
1974	83.8	195.6	131	150
1971-74 avg	94.6	191.9	147	147

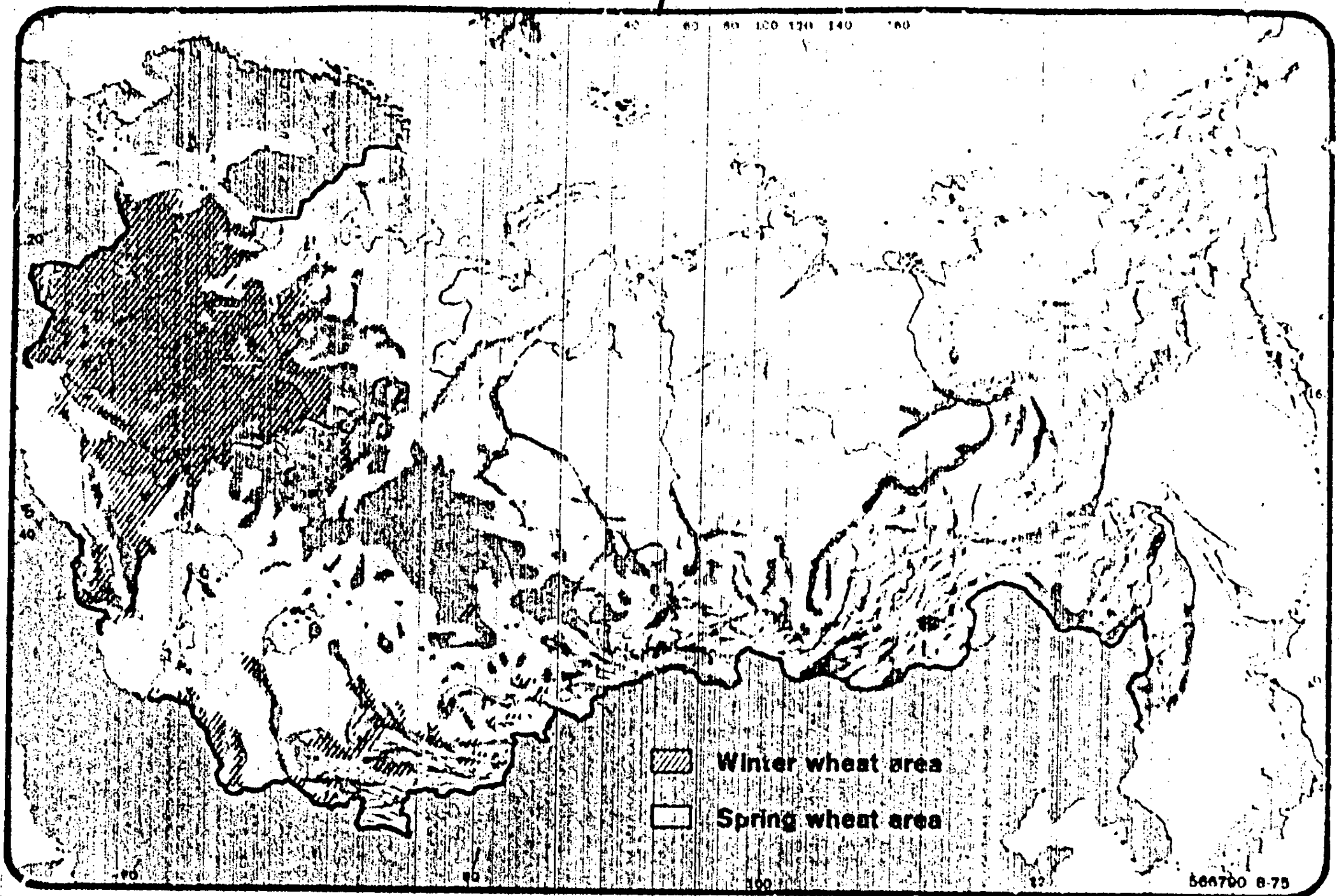

Figure 1. USSR: Wheat Cultivation Areas

Table 3

USSR: Distribution of Wheat Production By Economic Regions, 1970

Region	Percent of Total*		
	Winter Wheat	Spring Wheat	All Wheat
RSFSR, total	51	72	63
Region in RSFSR:			
Northern Caucasus	31	Insig.	13
Volga region	7	21	15
Western Siberia	Insig.	19	11
Urals region	Insig.	17	10
Eastern Siberia	Insig.	7	4
Central Black Soil Zone	7	2	5
All other regions	6	6	5
Ukraine and Moldavia	38	Insig.	16
Kazakhstan	3	28	17
Belorussia	2	Insig.	1
Transcaucasus	2	Insig.	1
Central Asia	2	Insig.	1
Baltics	1	Insig.	1

*Rounded to nearest percent.

Belorussia, but substantial winter wheat area also is located in other zones of the RSFSR before spring wheat gradually supplants it in the northeast portion of European USSR. Winter wheat also is widely grown in Central Asia, the Transcaucasus, and southern Kazakhstan. Winter wheat seeding begins in northeast European USSR in August and is completed in the southern regions during October.

The basic regions of spring wheat production, besides the Urals and Volga regions of northeast European USSR, are western and eastern Siberia and northern Kazakhstan.[5 6 9] In some areas spring wheat overlaps the winter wheat zone. Practically all of the durum wheat grown is the spring wheat type. The main areas of durum cultivation are the lower and middle Volga regions, Orenburg Oblast, and Kazakhstan where the climatic conditions are most favorable for producing the high quality of durum wheat desired.[10]

THE ROLE OF VARIETIES IN INCREASING SOVIET WHEAT PRODUCTION

Soviet wheat yield per hectare has been trending upward since World War II.[11, 12] The rate of increase slowed in the early 1960s but subsequently accelerated, and the average yield during 1971-73 almost doubled the 1951-55 level. Neither winter wheat nor spring wheat yields, however, have increased relatively faster than did the average yield of all grains (table 4). The largest single boost to wheat and to all grain yields has been the rapid increase in the use of chemical fertilizer, particularly in the last decade. Deliveries of chemical fertilizers to agriculture in 1974 were almost six times the 1960 level. Also since the 1950s Soviet farms have gradually acquired more and better agricultural machinery, permitting them to till more land, to cultivate on a more timely basis, and to adopt improved tillage and cropping practices. The productivity of substantial tracts of land was improved with liming, drainage, and irrigation. More abundant supplies of pesticides permitted improvements in the control of insects and diseases.

The lack of sufficiently modern varieties is one of the serious limitations to continued increases in Soviet grain production—because present varieties limit the yield response from other inputs. Compared to most industrialized countries, Soviet grain production technology still suffers severely from significant shortcomings such as a notable lack of sophistication in agricultural mechanization and lower rates of fertilizer, herbicide, and insecticide application. As the Soviets overcome this gap in their farming practices, the limitations of their wheat varieties will become more of a factor in yield rates.

APPRAISAL OF SOVIET WHEAT VARIETIES

Russian wheat varieties, in general, have long enjoyed an excellent international reputation among scientists and wheat growers. Many old Russian varieties of wheat, which were transplanted abroad by emigrants and scientists, proved invaluable for direct planting and for use in breeding new wheat varieties. Many of these old varieties as well as their progeny are still grown in the USSR. The Soviet-developed winter wheat variety, Bezostaya-1, gave the highest yield in the 1969, 1970, and 1972 International Wheat Performance Trials. It was one of the three most

Table 4

USSR: Yields of Wheat, Selected Years

(Quintals per Hectare)

Year(s)	All Wheat	Winter Wheat	Spring Wheat	All Grain
1951-55 avg	8.4	11.1	6.6	8.0
1956-60 avg	10.6	14.6	9.8	10.1
1961-65 avg	9.7	15.3	6.2	10.2
1966-70 avg	13.4	19.6	11.1	13.7
1970	15.3	22.8	12.3	15.6
1971	15.4	23.1	11.8	15.4
1972	14.7	19.6	13.0	14.0
1973	17.1	26.9	13.1	17.6
1974	14.0	21.0	9.5	15.1

productive varieties in the 1971 trial and ranked high in the 1973 trials.[24] In the test reports, Bezostaya-1 was consistently cited for its unusually wide range of adaptation and its stability of yields over a wide range of environments.

The predominant Soviet spring wheat variety Saratovskaya-29, especially when grown in certain regions of the Volga and east of the Urals, has an international reputation for producing grain of excellent bread making qualities.[25] Selected lots of this variety, under the grade label SK-14, command a premium price in West European markets comparable to or higher than the prices paid for wheats recognized as the standard of excellence, namely those raised on the northern Great Plains of the U.S. and Canada.

There are, however, some very serious shortcomings in the Soviet inventory of wheat varieties. The USSR's heavy dependence on a few, rather old varieties is cause for concern by the Soviets. In recent years, Bezostaya-1 and Mironovskaya-808, have each occupied over 40 percent, and together about 85 percent, of the winter wheat area in the USSR (table 5).

In 1973, Bezostaya-1 was grown worldwide on more than 13 million hectares, including more than 8 million hectares in the USSR.[26] It is grown primarily in the Balkans, also sown in southeastern Poland and Czechoslovakia, and has been introduced in Turkey, Iraq and Afghanistan. Similarly Mironovskaya-808 is grown extensively in Czechoslovakia, Poland, East Germany, and Hungary.

Saratovskaya-29 accounts for over 45 percent of the USSR's nondurum spring wheat area and Kharkovskaya-46 durum wheat accounts for practically all of the durum wheat area (table 6). Since these key varieties are not universally adapted, their concentration in the areas where they are grown is, of course, much greater than in the USSR as a whole. In many regions, the wheat acreage is exclusively devoted to a single variety. Tables 4 and 5 show that only a few other varieties have occupied the bulk of the remaining wheat area. All of the predominant wheat varieties were developed and introduced in the late 1950s or earlier. It has been economically advantageous to the USSR to grow the popular varieties extensively but dependence on the popular varieties makes Soviet wheat production particularly vulnerable to their limitations. The bulk of the 77 varieties of winter wheat and the 100 varieties of spring wheat, which were listed in 1973 as approved for commercial growing in one or more localities of the USSR, are severely limited in terms of adaptation and performance.[27] The Soviet inventory fails to meet the varietal requirements of the wide variation of climate and soil conditions found in various individual crop regions. There is a lack of promising new varieties needed to replace old varieties that are becoming increasingly obsolete. Overall, Soviet commercial wheats have some basic faults which the Soviets must overcome if they are to modernize their wheat varieties.

Lack of Disease Resistant Varieties

Soviet wheat varieties characteristically lack comprehensive resistance to various types of pests and diseases.[124] According to one Soviet estimate the average annual losses of grain from disease alone is one billion poods (over 16 million tons).[28] Diseases attacking Soviet wheat include powdery mildew, common bunt, loose smut, collar rot, snow mold, and three forms of rust (leaf, yellow, and stem).[19, 30] Leaf rust is the most widespread in the USSR and Soviet wheat varieties have a low resistance to this pathogen. Wheat is attacked severely by rust in one or more agricultural regions almost every year. Prior to 1973 the Soviets were estimating that rust reduced the average annual USSR winter wheat output by 5 percent, and spring wheat by 3 percent, with losses on individual fields frequently reaching 10 to 15 percent or more. Each one percent loss of Soviet wheat output currently represents approximately one million tons of production.

Outbreaks in 1973 and 1974 of new, aggressive strains of wheat leaf rust have revealed a much more serious rust problem. In 1973, 2 years after two new, high yielding (up to 100 quintals per hectare) and highly touted winter wheat varieties, Avrora and Kavkaz, were approved for commercial growing in designated regions (zoned), an outbreak in Krasnodar Kray of new leaf rust biotypes reduced yields of these varieties by 25 to 50 percent.[31, 35] Bezostaya-1, the predominant variety in the Kuban which Avrora and Kavkaz were scheduled to replace, is also attacked by the new biotypes though it apparently is more tolerant than the new varieties. Indeed concentrating production in Bezostaya-1 may have contributed to the buildup of the leaf rust biotypes.[37] In 1974, leaf

Table 5
USSR: Areas Devoted to Winter Wheat Varieties, Selected Years[1]

Variety	Year First Zoned	1965	1966	1967	1968	1968 As Percent of Total[3]	Remarks
		Thousands of Hectares					
Bezostaya-1	1959	6452	6916	7485	7184	42	About 8 million hectares in 1973
Mironovskaya-808	1964	586	3127	6260	7083	42	Over 9 million hectares in 1972
Odesskaya-16	1952[2]	998	964	626	412	2	
Priazovskaya	n.a.	507	507	318	305	2	
Ulyanovka	n.a.	516	445	393	283	1	
Lutescens-230	n.a.	428	152	149	231	1	
Odesskaya-3	n.a.	548	449	423	227	1	
Krasnaya Zvezda	n.a.	125	167	17	216	1	
Belotserkovskaya-198	n.a.	3311	2185	612	208	1	
Pshenichno-Pyreynyy Gibrid-186	n.a.	237	210	200	137	1	
Stepnaya-135	n.a.	327	281	118	109	1	
Surkhak Yubileynyy	n.a.	69	82	80	89	Insig.	
Kooperatorka	n.a.	73	65	63	59	Insig.	
Veselopodolyanskaya-485	n.a.	1	14	50	54	Insig.	
Lutescens-266	n.a.	123	136	86	49	Insig.	
Dotnuvskaya-458	n.a.	118	57	60	45	Insig.	
Bel'tskaya-32	n.a.	121	157	104	45	Insig.	
Pshenichno-Pyreynyy Gibrid-599	n.a.	113	69	57	43	Insig.	
Ukrainka	1924	156	105	55	43	Insig.	
Kazakhstanskaya-126	n.a.	16	32	26	35	Insig.	
Mironovskaya-264	1960	1926	325	183	30	Insig.	
Ferrugineum-1239	n.a.	245	186	80	19	Insig.	
Priazovskaya Uluchshennaya	n.a.	....	....	....	16	Insig.	
Novoukrainka-83	n.a.	26	28	23	15	Insig.	
Kharkovskaya-4	n.a.	....	1	....	1	Insig.	
Bezostaya-4	1959	10	....	....	....	....	
Local Krymka	n.a.	9	2	1	....	....	
Il'ichevka	1974	....	....	....	....	....	Plan 1 million hectares in 1975
Avrora	1971	....	....	....	....	....	200 thousand hectares in 1973
Bezostaya-2	1971	....	....	....	....	....	
Kavkaz	1971	....	....	....	....	....	900 thousand hectares in 1973
Al'bidum-114	1973	....	....	....	....	....	
Donetskaya-74	n.a.	....	....	....	....	....	
Mironovskaya Yubileynyy-50	1969	....	....	....	....	....	
Odesskaya-51	1971	....	....	....	....	....	Plan 1 million hectares in 1975
Odesskaya-26	1962[2]	....	....	....	....	....	
Krasnodarskaya-39	1972	....	....	....	....	....	
Kharkovskaya-55	n.a.	....	....	....	....	....	
Priboy	1972	....	....	....	....	....	
Kharkovskaya-63	1974	....	....	....	....	....	
Novosibirskaya-67	1972	....	....	....	....	....	
Dneprovskaya-521	1973	....	....	....	....	....	
Nemchinovskaya-154	1972	....	....	....	....	....	
Total of Varieties Listed		17041	16662	17468	16938		
Unlisted Zoned Varieties		2015	2621	1815	1588		
Other Varieties		400	520	479	446		
Total Winter Wheat Area		19456	19803	19762	18972		
Total of Zoned Varieties		19056	19283	19283	18526		
Percent of Total		98	97	98	98		
Total of Strong Wheats		13076	13893	15000	14068		
Percent of Total		67	71	76	73		

[1] Areas listed for 1968 and previous years probably include only that of kolkhozes and sovkhozes.
[2] Date developed (sent to testing).
[3] Percent of total hectares listed.

Table 6

USSR: Areas Devoted to Spring Wheat Varieties, Recent Years

Variety*	Year First Zoned	1970 Million Hectares	1970 Percent of Total Spring Wheat Area	Remarks
Saratovskaya-29	1957	16.7	37.3	About 16 million hecares in 1971 and 18.5 million hectares in 1973
Bezenchukskaya-98	1951	4.5	10.0	
Khar'kovskaya-46*	1957	4.2	9.4	
Albidum-43	1946	3.0	6.7	3.5 million hectares in 1973
Lutescens-758	1947	2.6	5.8	1.2 million hectares in 1973
Skala	n.a.	2.1	4.7	Over 2 million hectares in 1972-73
Lutescens-62	1911	1.5	3.3	527,000 hectares in 1973
Milturum-553	1940	1.1	2.5	
Saratovskaya-210	1954	1.2	2.7	In 1973, occupied with Saratovskaya-38 1.9 million hectares
Saratovskaya-38	1962	.74	1.7	
Saratovskaya-39	1968	.73	1.6	870,000 hectares in 1973
Saratovskaya-36	1963	.72	1.6	1.9 million hectares in 1973
Melanopus-26*	1956	.70	1.6	
Erythrospermum-841	1915	.50	1.1	
Vesna	1969	.48	1.1	600,000 hectares in 1974
Diamant	1940	.43	1.0	
Onokhoyskaya-4	n.a.	.30	.7	
Strela	n.a.	.27	.6	
Narodnaya*	1947	.25	.6	
Otechestvennaya	n.a.	.24	.5	
Saratovskaya-33	1963	.23	.5	458,000 hectares in 1973
Kzyl-Bas	n.a.	.23	.5	
Milturum-321	n.a.	.20	.4	
Amurskaya-74	n.a.	.17	.4	
Amurskaya-75	n.a.	.16	.4	
Kazakhstanskaya-126	n.a.	.16	.4	
Kometa	n.a.	.12	.3	
Dal'novostochnaya-4	n.a.	.11	.2	
Baskhirskaya-4	n.a.	.11	.2	
Zhana-Kyzyl	n.a.	.10	.2	
Chitinskaya-1	n.a.	n.a.	n.a.	
Pallidum-394	n.a.	n.a.	n.a.	
Krasnoyarskaya-1	n.a.	n.a.	n.a.	
Onokhoyskaya-4	n.a.	n.a.	n.a.	
Novosibirskaya-7	n.a.	n.a.	n.a.	
Novosibirskaya-67	1972	n.a.	n.a.	
Pirotrika-28	1972	n.a.	n.a.	
Moskovskaya-21	1972	n.a.	n.a.	
Moskovskaya-35	1972	n.a.	n.a.	
Saratovskaya-42	1973	n.a.	n.a.	18,000 hectares in 1973
Saratovskaya-44	n.a.	n.a.	n.a.	
Saratovskaya-40*	1974	n.a.	n.a.	None
Saratovskaya-41*	1975	n.a.	n.a.	None

*An asterisk denotes durum varieties; all other varieties are common wheat.

rust was severe in most of the Soviet winter wheat area including the central and lower Volga, parts of the Ukraine, the Baltics and in northwestern RSFSR.[36] Despite a relatively good harvest, yields in many winter wheat areas were as much as 20 percent below expected levels. The new biotypes are capable of infecting most commercial varieties of both winter and spring wheat and many of the experimental varieties in advanced stages of development. Treatment with fungicides is not a feasible means of control. Therefore, epiphytotics of leaf rust will continue to be a severe threat until new wheat strains with the requisite resistance are developed.

Low Resistance to Insects

Insect pests causing significant damage to Soviet wheat include the Hessian fly, frit fly, the green-eyed fly, senn insect (Eurygaster intergriceps Put.) cereal leaf beetle, and grain sawfly.[39] There are relatively few Soviet insect-resistant grain varieties. For example, Avrora and Kavkaz have been very severely damaged by wheat sawfly.[40] The senn insect is of particular concern to the Soviets because it reduces not only wheat yields but also grain quality. Damage to as little as 2 to 3 percent of the grain kernels apparently renders the entire lot of flour unsuitable for milling.[41] Systematic breeding for grain insect resistance in the USSR has been neglected and is carried on at only one institute. The lack of insect-resistant wheat varieties puts the burden of wheat control on cultural measures and pesticides.[42]

Susceptibility to Lodging

Soviet wheat varieties generally lack sufficient resistance to lodging.* Recent Soviet studies indicate that 6 to 15 percent losses in grain yields because of lodging are not unusual.[43] In rainy years, lodging can be catastrophic with losses of yield up to 50 percent and a sharp reduction in grain quality. Losses due to lodging have worsened in recent years as fertilizer and other agrotechnical improvements were increased. All of the predominant Soviet varieties, both winter and spring including some varieties classified as "resistant," have lodged severely.[44] The proneness of Soviet wheat varieties to lodging is indicated by their relative height. For example, Bezostaya-1, one of the most resistant, is moderately short, 35 to 40 inches.[45] In comparison, US high yield wheat varieties, such as Gaines, have stem heights of 25 to 29 inches.

To compensate for the lack of lodging resistant varieties, the Soviets make extensive use of a chemical growth retardant, CCC (trimethyl-beta-chlorethylammonium chloride or chlorocholinechloride, designated TUR in the Soviet Union) as a means of reducing lodging in cereal crops.[46] [47] CCC is used with benefit in northern Europe and England. The Soviets believe CCC also improves winter hardiness of wheat and increases winter wheat yields. In 1971, the Soviets claimed that 10 to 15 million tons more grain could be produced per year if crops were properly treated with CCC. While the extent of CCC use in the USSR is not known, the claim of potential benefits is an indication of the extent of losses from lodging and winterkill.

Propensity for Shattering

Soviet experiments have measured "shattering" losses of 7 to 27 percent in connection with 5- to 15-day delays in harvesting after grain reaches full ripeness.[48] The term shattering refers to wheat kernels falling from ripened heads before they can be threshed so that they are lost on the ground. On the average about 50 percent or more of the Soviet grain area is harvested by the more costly two-phase system rather than direct combining. The widespread use of the two-phase system reflects in part the tendency of Soviet wheat varieties to lodge and to shatter. Under the two-phase system, grain that is mature but not fully dry is first cut into windrows. Later it is gathered and threshed with combines. The longer the grain remains uncut after it has matured, the more vulnerable it becomes to shattering. Many other factors contribute to overcoming the ability of grain to remain standing and intact until the crops becomes ready for direct combining. These include: uneven ripening of grain heads; slow drying conditions after the grain has become physiologically mature; attacks by birds; insect and disease damage; high winds; and driving rains or snow. Under the direct combining system

* Lodging is a condition whereby wheat stalks lean, bend or break and result in a flattened and sometimes tangled mass. If this occurs before the grain crop has matured, it interferes with the development and filling of the grain heads. Later it makes it difficult to harvest the grain without losses of yield and quality. The extent of actual losses from lodging varies with the stage of crop development and the kind and severity of weather factors. Also, the more lush, taller growth habit of the plants and the heavier weight of the heads under conditions of abundant fertility and moisture impose an increased load on the wheat stem, making it more prone to lodging.

grain is cut and threshed simultaneously. In prolonged wet weather, however, standing grain dries faster, whereas windrowed grain is more prone to deteriorate from dampness. Thus, resistance to lodging and shattering would increase yields, protect grain quality and reduce harvesting costs. This resistance is especially important where concentration of wheat acreage usually involves some delays in harvesting after the grain is ripe.

Inadequate Winter Hardiness and Drought Resistance

Large losses of wheat plantings due to winterkill are a frequent phenomenon in the USSR. In recent years losses averaged 15 to 20 percent; in severe winters up to one-third of the fall planted grains perished.[49-51] In Odessa oblast during 1958-1971, losses due to winterkill averaged 28 percent of the area sown. While cultivation practices play a role, the lack of sufficient hardiness in the varieties planted, particularly Bezostaya-1, is a prime factor in these losses. The most winter-hardy varieties in the world were developed in the USSR, but even these varieties do not assure complete survival of the crop under the severe winters of the USSR. The major problem, however, is that the USSR's winter hardy varieties are not sufficiently productive.[53]

The Soviets judge drought resistance to be the most important characteristic of spring wheat varieties. Despite significant improvement, Soviet spring wheats are not adequately drought resistant, especially the durum varieties. Similarly, shortfall of precipitation is the main limitation to winter wheat yields. Although the protein content and overall quality of wheat produced under conditions of moisture stress tend to be high, the primary effect of drought is a limitation of yields. The yield of flour is further reduced by the presence of shriveled kernels.

Declining Wheat Quality

Variety characteristics also contribute to the problems of declining wheat quality in the USSR. The Soviets frequently complain that much of their wheat is of poor quality, in terms of both the condition of the grain and the type of grain produced.[54] The protein content is of particular concern in the USSR since their wheat varies, by areas as well as by years, from a high of 18 percent to a low of 8 percent in protein content.[55-58] Moreover, the increase in yields has been accompanied by a decline in protein content. Low protein content could significantly affect the quality of bread, which is so important to the Soviet diet. Currently, Soviet consumption of grain products (flour equivalent) is 145 kilograms per capita, compared to 58 kilograms in the US. Although a restructuring of the rates and methods of fertilizer application would help the USSR, more importantly the timely and periodic updating of wheat varieties would improve the protein content of their wheat as well as increasing yields.

The Soviets also are concerned with shortfalls in the quality of the protein which is reflected in the milling and the baking qualities of their flour. The international reputation of Saratovskaya-29 notwithstanding, the Soviets have a relative shortage of excellent wheat for milling and baking needs as well as an acute shortage of durum wheat for making macaroni type products.* These shortfalls are partly due to improper identification of wheats passing through marketing channels. Wheat of otherwise high quality frequently is rejected for minor faults, e.g. content of extraneous materials.[59] In 1971, two-thirds of the total wheat area (55 percent of the spring wheat and 89 percent of the winter wheat) was planted to varieties currently rated by the Soviets as capable of producing high quality flour. These varieties, however, are grown where they produce the highest quantity yields and not necessarily where they interact with soil and climate to produce the highest quality wheat. For example, Kharkovskaya-46 durum wheat accounts for 80 percent of all durum wheat raised, yet 36 percent of the price premiums paid for durum wheat during 1967-1972 were expended for

*Wheats, and the resulting flour are classified according to breadmaking characteristics. Flour from strong wheat, the most valuable, is comparatively high in protein, absorbs a relatively large amount of water, withstands much mixing, tolerates prolonged periods of fermentation, and provides well-shaped loaves of good porosity and large volume. Flour from the so-called weak wheats absorbs a relatively small amount of water and the dough rapidly deteriorates in the process of fermentation and handling, becoming liquid, inelastic, sticky and smeary, and the bread is flat with coarse or dense porosity. Properly blended, strong wheat flour improves the breadmaking characteristics of lower quality flours so they can be used in mechanized breadmaking. Strong wheats are called "improver" wheats and are in great demand. Wheats termed "filler" wheats have good baking qualities but cannot substantially improve weak wheat.

substandard quality grades. Similarly all but 10 percent of the wheat procured under the strong rating is obtained from Kazakhstan, even though the RSFSR plants the same wheat varieties on the same size area.

Poor Maturity Dates and Growth Habits

The large Soviet inventory of wheat germ plasm has been insufficiently utilized for developing well adopted varieties for all of the diverse agroclimatic in the USSR. Peculiar growing conditions in the USSR regions preclude the widescale, direct transfer of foreign varieties. A variety well adapted to a given region effectively utilizes the season favorable for its growth and development and still matures in time to avoid harmful effects of postseason weather.[61 63] Thus, the southern Soviet areas need winter varieties that develop before the onset of high temperatures associated with summer. On the other hand, success in extending wheat plantings into regions of extremely short growing seasons (the taiga zone of Siberia and the Urals, and certain mountainous zones) is restricted by a lack of early maturing spring varieties. Earlier maturing varieties are needed also for western Siberia and northern Kazakhstan where the predominant varieties do not always ripen before the onset of frosts. Frost damage reduces both the yield and quality of the grain and the resulting flour. Damage varies with the severity of the frost and the immaturity of the kernels. Very green kernels turn black whereas more mature kernels may suffer only a blistering of the kernel surface. Failure to vary the maturity dates of the varieties grown concentrates harvesting work, adds to strain on workers and equipment, and increases losses of grain and costs of harvesting. Variety selection must be coordinated with other agrotechnical changes. In the New Lands, for example, phosphorous fertilizers hasten ripening by 5 to 6 days and in some years by 10 days.[64] Similarly, seeding of spring wheat in the New Lands is purposely delayed, to control weeds and to delay plant development until precipitation and temperature become more favorable later in the season.

In recent years, the sprouting of unharvested wheat in the field has been a severe problem, particularly in the nonchernozem and northwest zones of the USSR.[65] The action of enzymes associated with germination of the wheat kernel adversely affects its value for milling and baking. Ripened grain will not germinate if it is kept dry. Moreover, there is a period after wheat reaches maturity when it will not germinate even under conditions otherwise conducive to sprouting. Varieties vary in the duration of this rest period which should prevent grain from germinating before it can be harvested and dried for storage but should not interfere with the fall planting of the next year's winter wheat crop.

RECENT EFFORTS TO IMPROVE WHEAT VARIETIES

Since the 1950s, the Soviets have devoted considerable effort to developing new winter wheats from the Bezostaya-1 line of breeding. It has been heavily used as a parent or its breeding repeated in the hopes of improving its good qualities and correcting its undesirable traits*[79] (table 7). A number of progeny have been zoned, but none emerged as a worthy replacement to Bezostaya-1.

Bezostaya-1 crossbred with Mironovskaya-808 resulted in the development of Il'ichevka and Yubileynaya-50. Despite widespread publicity accorded to these new varieties, it is doubtful that they will be widely used (Appendix C). Avrora and Kavkaz were the most highly acclaimed of the Bezostaya-1 progeny. To derive them, the German variety Neusucht was crossed with Bezostaya-4 and the progeny backcrossed to Bezostaya-1.[65] Selection then produced Avrora and Kavkaz, and also Bezostaya-2 which received much less attention. Developed in 1967 and zoned in 1972, Avrora and Kavkaz produce higher yields than Bezostaya-1 under favorable conditions. They are, however, inferior in baking quality, winter hardiness, and resistance to drought. Of course, their most serious fault is susceptibility to the new biotypes of leaf rust. Until 1973, P. P. Luk'yanenko, the breeder of these varieties, believed high resistance to rust was one of their strong attributes.

The large winterkill losses in 1969 and 1972 and the 1972 drought focused attention on the need for productive varieties with greater hardiness for the

*Fifty eight newly developed Soviet varieties have been obtained crosses involving Bezostaya-1 or its initial cultivar Bezostaya-4. In addition, the highest yielding new varieties in Bulgaria as well as some new varieties in Hungary, Russia, Rumania, Yugoslavia, and France incorporate Bezostaya.

Table 7

Partial Listing of Soviet Wheat Varieties Developed From Bezostaya-1 or Bezostaya-4 Germ Plasm

Variety	Other Germ Plasm Used
Using Bezostaya-1	
Avrora	Lutescens-314-h-1417 [1]
Kavkaz	Lutescens-314-h-1417 [1]
Bezostaya-2	Lutescens-314-h-1417 [1]
Priboy	Odesskaya-16
Odesskaya-51	Odesskaya-16
Yuzhanka	Odesskaya-16 and Belotserkovskaya-198 [2]
Yuzhoukrainka	Odesskaya-16 and Odesskaya-22 [3]
Novostepnyachka	Odesskaya-29
Krasnodarskaya-39	Saratovskaya-3
Kharkovskaya-63	Mironovskaya-808
Moskovskaya-35	Minskaya
Moskovskaya-21	Minskaya
Stepnaya-40	An unidentified, cold-resistant variety
Lutescens-39	An unidentified, cold-resistant variety
Severokubanskaya-43	An unidentified, cold-resistant variety
Using Bezostaya-4	
Chernomorskaya	Odesskaya-16 [4]
Mironovskaya Yubileynaya-50	Mironovskaya-808 [5]
Il'ichevka	Mironovskaya-808
Rannaya-12	Skorespelka-3 [6]
Skorospelka-35	Lutescens-9411

[1] Neusucht (German) crossed with Bezostaya-4.
[2] Probably a mixture of the pollen of these varieties.
[3] A mixture of the pollen of these varieties.
[4] At least three selections of Chernomorskaya were made: -406/70; -468/70; and -478/70.
[5] In the form of Lutescens-106 from which Mironovskaya-808 was selected.
[6] Of the same parentage as Skorospelka-2 (Klein-33 x Kanred-Fulcaster-266289).

southern Ukraine and North Caucasus. Despite the southernly location of these areas and the proximity to the Black Sea, they frequently experience drought or cold which Bezostaya-1 cannot withstand. In late 1972 the State Commission on Seed Testing of Agricultural Crops after only limited brief testing, zoned a set of new varieties for use in the southern Ukraine and north Caucasus areas. These varieties include Priboy, Krasnodarskaya-39 and Al'bidum-114.[79, 82]

Priboy was obtained at the All-Union Plant Breeding and Genetic Institute by crossing Bezostaya-1 with Odesskaya-16. Odesskaya-16 was developed in 1952 in an effort to find (by selection) suitable varieties for southern Ukraine. Odesskaya-16 has high drought resistance and winter hardiness, is resistant to shattering and lodging, and possesses good baking qualities. Table 7 shows various attempts to combine the attributes of Odesskaya-16 with the higher productivity of Bezostaya-1 and of Bezostaya-4. Priboy is perhaps the best of the cross breeding using Odesskaya-16.

A variety called Odesskaya-51, was bred identically to Priboy and was released 3 years ago; it is reportedly grown on one million hectares.[83, 85] Priboy was developed in 1969, first zoned in 1973, and its zoned area is to be increased in 1975. It is still uncertain whether Priboy combines high adaptability to variation in weather, strong winter hardiness, drought resistance, and good baking qualities, with high productivity including resistance to lodging. In yield trials Priboy equaled or surpassed Bezostaya-1, Mironovskaya-808, Kavkaz and Avrora under steppe conditions, and its yield advantage is said to increase as growth conditions become less favorable.

Krasnodarskaya-39, zoned for portions of the eastern half of the Bezostaya-1 zone, was developed at the Krasnodar Institute. It apparently successfully blends the relatively high productivity and resistance to lodging of Bezostaya-1 with the higher winter hardiness and drought resistance of its other parent Saratovskaya-3. Reportedly, its baking qualities are good and it resists shattering. Unlike Priboy, it was not approved for additional areas in 1975.

In order to derive a new wheat with sufficient winter hardiness for the Volga and Central Black Soil Zones, Soviet breeders were forced to rely again on the relatively simple process of selection from local varieties. Al'bidum-114 was selected at the Kinel' Plant Breeding Station from Al'bidum-11. It is described as one of the most winter-hardy of Soviet varieties and above average in drought resistance, but it does not appear to rate more than average in other important traits. Although zoned prior to 1973, apparently it is not competitive in areas where Mironovskaya-808 is adapted.

New varieties for the spring wheat regions are also being sought. Saratovskaya-29 and Bezenchukskaya-98 largely owe their popularity to their relatively excellent grain quality. These two varieties and Khar'kovskaya-46 durum wheat dominate RSFSR and northern Kazakhstan wheat lands. The Soviets believe, however, they are not providing sufficient yields, particularly in the New Lands which are rather distant from Saratov and Kuybyshev oblasts where these varieties were developed. After a number of attempts failed to develop alternative varieties, Pirotriks-28 was developed in 1969, first zoned in 1973 and its area will be expanded in 1975.[86] It was selected from Shortaninka, sometimes described as an old local variety but actually stemming from the Canadian variety Marquis. It is by no means sure that Pirotriks-28 will be competitive. On a grade scale of 1 to 5, the bread making qualities of Pirotriks-28 rate 3.2 to 4.2 compared to Saratovskaya-29 and Bezenchukskaya-98 ratings of 4.5 to 5.0. Moreover, Pirotriks-28 tends to lodge and to shatter, particularly when precipitation is abundant in the latter part of the growing season and during harvesting. Finally, even its yield advantage is in doubt.

Of the 15 types of spring wheat now being produced in the northwestern, central, and Volga-Vyatsk regions of the nonchernozem zone, and in the central Urals region, all can be traced back to the VIR collection.[87] New varieties recently made available to these regions include Novinka and Severyanka. Severyanka and perhaps Novinka also can be traced to the Canadian Marquis variety.[88] Takhti, a variety from Finland, is intended for use as breeding stock to correct the problem of wheat sprouting in unharvested heads.[89] Soviet efforts to develop new wheat varieties can be judged by the most recent additions to the list of zoned varieties.[90] For growing in 1975, 14 new wheat varieties were initially zoned and 10 other varieties were approved for growing on an expanded area (Table 8). None of these varieties, however, offer a significant contribution to modernizing Soviet wheat varieties.

The new winter wheat variety Donskaya Ostistaya, approved for "important wheat areas" of the northern Caucasus, is designated as a strong wheat variety but its pedigree is not known. It is possible this variety is Donskaya-74, which successfully passed field testing for the third year. Another unknown, Polesskaya-70, is approved for five more oblasts in the Ukraine. The extension of Il'ichevka (to ten of the Ukraine's less important grain producing oblasts), Priboy and Orbita is of lesser significance. Nakat is a spring durum wheat newly zoned in Odessa Oblast (southern Ukraine) to reseed areas where fall sown winter wheat does not survive the winter. Though not yet zoned, another new variety Mironovskaya-808 spring wheat is described as an "insurance version" which Soviet scientists intend for supplemental seeding where Mironovskaya-808 has been partially damaged (thinned) by winter kill. Reportedly the spring and winter versions do not differ in morphological characteristics.[91] Up to now winter wheat fields, completely or partially destroyed by winter kill were reseeded to spring grain, usually barley, and hence were lost to wheat production. Previously available spring wheats were not sufficiently productive and other grains had to be used for reseeding winterkill. Breeding of Nakat, and Svitanak began in 1962 but

Table 8

USSR: Wheat Varieties Given Initial or Expanded Zoning in 1975

Variety	Type of Wheat	Zoning	Area	Originating Institution
Donskaya Ostistaya..	Winter common	Initial	Important winter wheat areas	Zernograd State Plant Breeding Station
Przheval'skaya.......	Winter common	Initial	Irrigated regions of Central Asia	Przheval'skaya Strain Testing Station of Kirghiz
Il'ichevka...........	Winter common	Expanded	Ten oblasts in the forest steppe and forest zone of the Ukraine	Mironovka Scientific Research Institute for Wheat Breeding Selection and Seed Growing
Polesskaya-70........	Winter common	Expanded	Five Ukraine oblasts	Ukrainian Scientific Research Institute of Agriculture
Priboy..............	Winter common	Expanded	Two Ukraine oblasts	All-Union Selection and Genetics Institute
Orbita....	Winter common	Expanded	One Ukraine oblast	All-Union Scientific Research Institute for Corn
Dneprovskaya-521....	Winter common	Expanded	Southern Kazakhstan irrigated areas	All-Union Scientific Research Institute for Corn
Moskovskaya-35.....	Spring common	Initial	One oblast in Central Non-Chernozem Zone	Scientific Research Institute for Non-Chernozem Zone Central Regions Agriculture
Shortaninskaya-25....	Spring common	Initial	Turgay Oblast (Kazakhstan)	All-Union Scientific Research Institute of Grain Economy
Rang...............	Spring common	Initial	West and East Siberia	Sweden
Pompe..............	Spring common	Initial	West and East Siberia	Sweden
Zarnitsa............	Spring common	Initial	West and East Siberia	Krasnoyarsk Scientific Research Institute of Agriculture
Nakat..............	Spring durum	Initial	Odessa Oblast (Ukraine) (For reseeding winterkilled fields)	All-Union Selection and Genetics Institute
Saratovskaya-40......	Spring durum	Initial	Saratov (RSFSR) and Ural (Kazakhstan) Oblasts	Scientific Research Institute for Agriculture of the Southeast
Krasnokutka-6.......	Spring durum	Initial	Saratov and Volgograd Oblasts (RSFSR)	Krasnokutsk Experiment Station
Saratovskaya-41......	Spring durum	Initial	Ulyanovsk Oblast (RSFSR)	Scientific Research Institute for Agriculture of the Southeast
Saratovskaya-42......	Spring common	Expanded	Volgograd, Saratov, Orenburg, Rostov (RSFSR), Karagandin and Ural (Kazakhstan) Oblasts	Scientific Research Institute for Agriculture of the Southeast
Pirotriks-28..........	Spring common	Expanded	North Kazakhstan Oblast	All-Union Scientific Research Institute of Grain Economy
Novosibirskaya-67....	Spring common	Expanded	n.a.	Institute of Cytology and Genetics of the Siberian Branch of the All-Union Scientific Research Institute of Crop Growing
Grekum-114.........	Spring common	Expanded	n.a.	Main Botanical Garden of USSR Academy of Sciences
Lade................	Spring common	Expanded	n.a.	Norway
Kalyan Sona.........	Spring common	Initial	Irrigated lands of Volgograd Oblast	India
Sete Serros-66........	Spring common	Initial	Irrigated lands of Sukhandarin Oblast (Uzbek)	Mexico
Oviachik-65..........	Spring durum	Initial	Irrigated lands of Sukhandarin Oblast (Uzbek)	n.a.

State testing did not begin until 1972. Svitanak (a common spring wheat, not yet zoned) is a cross between a local Soviet variety and a Mexican dwarf variety, Centenario. Nakat is a cross of two Soviet varieties, one of which is a selection from a local spring durum variety. Both Nakat and Svitanak are termed highly resistant to drought and resistant to brown (leaf) and stem rusts, but it is doubtful their yields will compare with winter wheats.

Table 8 includes five foreign spring wheat varieties. For the first time foreign semidwarf wheats, Sete Serros-66 from Mexico and Kalyan Sona from India, have been approved for commerical growing in the USSR. Two varieties were obtained from Sweden and another from Norway. The varieties from Sweden plus a new Soviet variety (Zarnitsa) have been added to the choices for use in western and eastern Siberia. Northern Kazakhstan was zoned for one new variety (Shortaninskaya-25) and was approved for the use of Pirotriks-28 on a larger scale. The Volga, the Urals, and the nonchernozem zones were also given added choices: two durum varieties (Saratovskaya-41 and Krasnokutka-6) and a common variety Saratovskaya-42. Krasnokutka-6 and another common variety Saratovskaya-46 successfully resisted the 1974 epidemic of leaf rust and gave relatively high yields in the Volga region. Krasnokutka-6 also was resistant to drought and shattering.[93] Four of the new varieties were zoned for irrigated regions, indicating the emerging importance of these lands. Irrigation and other land reclamation currently account for one-third of the total agricultural investment.

Other spring wheats scheduled for expanded plantings in 1975 are Saratovskaya-42 and Novosibirskaya-67.[93 95] First zoned in 1972 for Altay Kray and extended in 1974 to Novosibirsk, Omsk and Tomsk Oblasts, Novosibirskaya-67 is the first wheat variety developed in a Siberian agricultural research center in the post-WWII period to be zoned for major grain areas of Siberia. Novosibirskaya-67 was derived through gamma irradiation of Novosibirskaya-7 by the Institute of Cytology and Genetics of the Siberian Department of the USSR Academy of Sciences. It is also the first mutant variety of spring wheat to be zoned in the USSR. It is described as approaching Saratovskaya-29 in quality of grain, being lodge resistant, not very susceptible to diseases, and better adapted to the climate of western Siberia. Zoned in 1974 but missing from the listing for 1975 are Moskovskaya-21 intended for parts of the nonchernozem zone, and four other Saratovskaya varieties (-44,-45,-46, and -47).[96] The Soviets expect these Saratovskaya varieties along with Saratovskaya-42 to compete with Saratovskaya-29 in the Volga, Urals and New Lands regions.

WHEAT VARIETY RESEARCH AND DEVELOPMENT

There is scarcely any recognized area of wheat breeding research where the Soviets are not to some degree either aware of or already involved. They are working in, perhaps overemphasizing, some areas which scientists abroad have neglected or ignored. The Soviet intent to modernize wheat varieties is reflected in projects to improve facilities for wheat breeding research, and in the US-USSR agreement for exchanging wheat and other crop germ plasm. While the pursuit of given areas of research, the existence of research facilities, or the selection of research goals do not guarantee success they are noteworthy for appraising future success in Soviet wheat breeding.

Construction of Phytotrons

The world's largest phytotron is under construction at the All-Union Institute of Selection and Genetics (Odessa) and is scheduled for completion by July 1975.[99-101] A phytotron is a structure in which scientists can grow plants under controlled conditions. An identical facility is to be built in Krasnodar and a somewhat smaller facility is being built at Mironovka. A number of centers already have phytotron facilities. Three generations of wheat can be grown per year, thereby accelerating research on new crop strains, fertilizer uses, and other agrotechniques. Better control of tests for winter hardiness, drought resistance, and resistance to diseases and pests helps to determine whether plants escape injury because they are truly resistant or because damaging conditions (e.g. infection, winterkill, moisture stress) did not occur. Coordinating the dates of flowering permits plants with different growth habits (maturity dates, climates adaptations, etc.) to be cross pollinated. Of course, phytotron crop research must be correlated with actual field conditions.

Seed Storage Laboratories

Facilities to contain and to expand the Vavilov collection are being developed. A new seed storage laboratory is under construction at the Kubanskiy Experimental Farm, 185 kilometers east of Krasnodar, and is to be completed in 1975.[102] It will match in size, if not exceed, the US National Seed Storage Laboratory at Fort Collins, Colorado, after which it was patterned.[103] Rather than going to a higher elevation for a suitable environment as the US did in the Rocky Mountains, two stories of the Soviet laboratory will be underground with the ground level story devoted to service work areas and offices. The laboratory will permit seeds to be stored for 15 to 20 years before they must be renewed to keep them viable. Both risks and costs will be lower than under current practice of regrowing the crops every few years. Five thousand specimens (of wheat, oats, and barley) were to be regrown in 1975. The Soviets probably consider the laboratory a part of an international network of genetic conservation centers recommended by the 1972 UN Conference on Human Environment.

Collection and Exchange of Wheat Germ Plasm

In the late 1940s and in the 1950s direct contacts between US and Soviet scientists aided the US search for crop germ plasm. By 1967, the USDA collection included 250 Soviet wheat varieties.[103] Under the 1972 US-USSR agreement to exchange agricultural information, the Soviets agreed to exchange by January 1975 computerized data (10 or more items) on each of the 20,000 wheats they consider their permanent collection. An additional 17,000 wheats are being evaluated. Later there will be a US-USSR exchange of oats, barley and rye collection lists, and eventually the entire US and Soviet seed collections will be exchanged.

Breeding of Short-Stemmed Varieties

As early as 1969, the Soviets had accumulated a large inventory of dwarf germ plasm, including the miracle wheats of the "green revolution."* [104-106] The collection includes strains from Mexico, India, Canada, Chile, Italy, and Israel. These spring wheats were short-statured and resistant to lodging. All were, however, susceptible to one or more biotypes of brown, yellow and stem rust, and almost all of them were susceptible to loose smut and dwarf bunt. An array of US short stem varieties also has been procured. These include several varieties obtained from World Seeds Inc. for testing beginning in 1971. The Soviets also have the original Norin-10 dwarf wheat and some dwarf strains of local origin from Turkmenia and Armenia. Currently research includes crossing the new spring wheat Nakat and Svitanak with American and Mexican short-stemmed varieties to develop high yield spring wheats. Finally, they are exploring the usefulness of induced dwarf mutants.

*The term "green revolution" refers to the spectacular increases in yields of crops, particularly of wheat and rice but also of corn, that were obtained in a number of countries—notably in Mexico, Pakistan, Turkey, and India. These yield increases followed the adoption of the recently developed and distributed, and widely publicized, "miracle" varieties.

Chemically Induced Dwarfs and Other Wheat Mutagens

Articles by P. P. Luk'yanenko, one in 1971 and one published posthumously in 1974,[104,106] described the Krasnodar Institute's use of nitromethylurea and other chemical mutagens to derive a number of dwarf mutants from standard Soviet winter wheats.[83] The most promising, a mutant of Bezostaya-1, is Krasnodarskiy Karlik-1 (also known as Dwarf Bezostaya-1) which evolved in 1966. Karlik-1 is described as short (50 to 60 cm), having good baking qualities, and exceeding other dwarfs and possibly Bezostaya-1 in winter hardiness. In ordinary years Karlik-1 reportedly yields up to 10 percent less, but in moist years and under irrigation 10 to 15 percent more than Bezostaya-1. Crossing of Karlik-1 with another variety resulted in a semidwarf variety which under irrigation outyielded the high performance of the Avrora variety. Many of the mutant dwarf wheats have a high protein content (16 to 20 percent), in sharp contrast to semidwarf wheats. The high protein content reportedly is retained during high yield conditions, especially under high inputs of nitrogen fertilizer.

Many international wheat breeding programs emphasize the semidwarf characteristic. A single dwarf genetic type, Norin-10 (from Japan) was used in the green revolution wheats, now grown on 26 million areas in Asia, Europe, Africa, and North and South America. The maxim "genetic improvement leading to genetic uniformity also contributes to genetic vulnerability," suggests all these wheats may be vulnerable to a given pathogen which may eventually become manifest. The Soviets believe induced mutants expand the range of genetic resources and remove the danger posed by a limited stock of dwarf germ plasm. Induced mutation, however, may simply rearrange germ plasm rather than change the genes. Akagomuki, dwarf ancestor of Bezostaya-1, may be a Norin-10 relative. It is not clear whether breaking genetic linkages between desirable and undesirable traits by induced mutagenesis provides a stable separation. Soviet mutation research also has created new forms of wheat using irradiation, such as pulsed light irradiation which produced Novosibirskaya-67.

Species and Genera Crosses

The Soviets have significant experience in crossing different species of wheats (interspecific crossing) and crossing wheat with nonwheat plants (intergeneric crossing).[107] Most of the interspecific crosses involve common and durum wheat. The winter durum varieties Michurinka and Novomichurinka are examples of such crosses. There is less evidence of Soviet success in crossing other wheat species though they recognize the wild species, particularly T. timopheevi and T. timonovum as potential sources of resistance to pathogens and of other desirable traits.

The Soviets claim they were "first to develop intergeneric crosses on a consistent and thorough basis." Their work has concentrated on crosses of wheat-rye and wheat-quack grass. At least two of the wheat-quack grass (Agropyrum glaucum) hybrids—Pshenichno-Pyreynyy Gibrid-186 and -599—were sufficiently promising to be zoned, though the area planted to them declined in the years following 1965 (Table 4). They are said to excel in yield, winter hardiness, and grain quality. Wheat-quack grass hybrids developed later were cited for their resistance to lodging under state testing near Moscow during the wet year of 1966.

After the discovery of a naturally occurring wheat-rye hybrid at the Scientific Research Institute for the Agriculture of the Southeast, the Soviets developed in 1931 a wheat-rye hybrid, a cross called triticale;* however, the wheat-rye hybrid Gibrid-46/131, apparently was not zoned. The Soviets reported good results in 1974 from their triticale experiments, on hundreds of hectares at many locations in the country. Their wheat-rye amphidiploids (2n-56) are said to be more winter resistant than the most winter hardy wheats (e.g. Ulyanovka) and are expected to extend winter wheats to Siberia. Some lines of trispecific triticale—rye, durum wheat and common wheat—are described as very winter hardy, much more hardy than Mironovskaya-808, and quite productive and resistant to diseases, especially smut.[111] [112] Their bread making qualities do not approach that of wheat.

Development of Hybrid Wheat

In wheat breeding, the term hybrid commonly refers to crosses between lines, species or genera. This use of the term should not be associated with hybrid corn or hybrid sorghum where heterosis (hybrid vigor) yields increases up to 35 percent over nonhybrid varieties. Wheat breeding does not yet permit commercial exploitation of heterosis, though scientists are hopeful of eventual success.[113] [114] Since wheat is naturally self-pollinating, crossing of two plants usually requires painstaking removal of the anthers from the plants selected as female stock, and introducing pollen from the other plant. The minuscule quantity of first generation seed from a given cross must be reproduced as self-pollinated plants to stabilize the genetic structure, obtain true breeding lines, and permit selection of the best crosses, and later to reproduce sufficient seed for commercial use. At this point in the process the hybrid vigor effect has been dissipated. In contrast, cross pollination of corn and sorghum produces commercial quantities of seed from the initial pollination. The discovery of male sterile strains reduced the cost of producing hybrid seed by eliminating the need for manual detasseling of corn and by controlling cross-pollination of sorghum under field conditions. The hybrid seed is produced on male-sterile plants pollinated by a male-fertile and fertility-restoring line. Plant breeders have developed male-sterile and restorer lines of wheat, but the failure to develop a sufficient propensity to cross-

*Plant breeders in many countries believe the new genus triticale, a cross of wheat (Triticum) and rye (Secale), will be the first man-made crop to compete with the traditional cereals.[108] [110] To be successful, triticale must combine the high total protein and gluten content of wheat with the high content of lysine amino acid found in rye, the greater yield potential of wheat with the greater adaptability of rye to unfavorable environment such as cold weather and light, sandy or acid soils, and retain the strong rust resistance of rye.

pollinate prevents the economical production of hybrid wheat seed. The Russians began research on hybrid wheat in 1965. Using cytoplasm of T. timopheevi and T. timonovum, they have obtained cytoplasmic male sterile (CMS) analogues of their popular winter wheat varieties, as follows: Bezostaya-1, Avrora, Kavkaz, Odesskaya-16, Odesskaya-51, Mironovskaya-808, Odesskaya-26, and Novomichurinka (durum). Various fertility restorers, including foreign varieties, have been tested. In 1966-70 experimental plots, seed produced by free wind cross-pollination of male sterile lines ranged from 15 percent to 70 percent of the levels expected from normal self pollination.

Salt Tolerant Varieties

The Soviets are conducting research to develop wheats with a tolerance for growing on saline soils, with a view of moving wheat production into some marginal lands and especially on irrigated lands. Some wheats obtained from Afghanistan remained productive under high osmotic tension while US and other USSR wheats become dwarf, sterile and unproductive.[115]

Breeding for Higher Protein Wheats

Several possible avenues for increasing both yield and protein content also are being explored in the USSR. The high protein germ plasm being investigated includes high protein varieties (e.g. Atlas-66), the products of mutagenesis (including Bezostaya mutants), and intergeneric (quack grass) and interspecific (wild emmer) hybridization.[116] In order to identify wheats high in lysine (the first lacking essential amino-acid of wheat), thousands of samples from the Vavilov collection have been analyzed at various centers. While no extremely high lysine wheats were located, samples with a relatively high content, up to 3.5 percent of total protein compared with 2.5 percent for standard Bezostaya-1, have been isolated.[117]

Rust Resistance Studies

Much of the US inventory of rust resistant wheat breeding stock was originally obtained from the southern regions of the USSR and the Mideast countries. Most of the Soviet commercial varieties recently tested in the US, however, were found to be resistant to only one or two of perhaps 15 races of rust recognized as significant threats.[118] Lysenkoism (Appendix A) undoubtedly was a particularly serious impediment to breeding work in rust resistance. More recently Soviet scientists have been aware of the need for improved rust resistance, they have monitored rust research in foreign countries, and have done research in the physiological and biochemical aspects of rust resistance. The Scientific Research Institute for the Agriculture of the Southeast and other centers have developed varieties with high resistance to diseases but these varieties were abandoned due to insufficient yield and grain quality.[119]

Whatever the causes of past failures, it is now of increasing importance that adequate rust resistance be incorporated into Soviet varieties. Moreover, success in reacting quickly to the immediate threat of the new leaf rust strains will depend on how much rust resistance has already been formulated into experimental varieties. As mentioned earlier, all of the leading winter wheat varieties and winter wheat varieties in advanced stages of development were susceptible to the new virulent biotypes of leaf rust. The threat of leaf rust is, of course, greatest in the winter wheat area. Nine spring wheat varieties submitted in 1974 to the State Commission for Crop Testing are described as relatively resistant to rust.[120]

Soviet wheat breeders now recognize much attention must be devoted toward developing varieties that are immunologically balanced. Their leaders urge a constant and comprehensive monitoring of the genetic makeup (the dynamics and variations) of rust and other pathogens, and a rapid placement of resistant varieties into production, once they are defined.

Soviet access to germ plasm pathogen resistance has never been better. Foreign varieties such as the Mexican dwarf or short stemmed varieties may also supply disease resistance. Strong resistance to rust was as important as short-straw in the development of these varieties. US scientists have been more selective in developing wheat varieties for rust resistance, especially to insure that all varieties were not resistant to the same biotypes. It is not apparent why the Soviets have not searched for resistant germ plasm in countries to the south, where disease spores, possibly even new biotypes, are likely to originate. Plans for developing rust resistant wheat varieties also include the use of intergeneric and interspecific crosses using wild forms of wheat and other grasses.

Persistence of Questionable Breeding Practices

While the extent of their application is not entirely clear, a number of Lysenko's precepts continue to be discussed in Soviet reports. For example, as late as 1967 P. P. Luk'yanenko reportedly endorsed and employed a wheat breeding technique of exposing uncastrated maternal varieties to a mixture of pollen. Sometimes he used pollen from a different crop, such as rye, in the role of a "sex mentor." He believed that this actually improved the genetic structure of the resulting wheat cross.[120] Other breeders also have subscribed to the "sex mentor" practice. Another example of Lysenko's concepts is that good growing conditions for the early generations of wheat crosses will somehow influence the genetic structure of the offspring. Similarly it is reported that P. P. Luk'yanenko subscribed to heavy applications of phosphorous-potassuim fertilizer as a means of raising rust resistance. Still another preoccupation implies that diversity in the geographic origin of varieties bred together somehow of itself has a beneficial effect for the resulting progeny. Tempting as it may be to dismiss these and similar reports from reality, they are too numerous to ignore in an overall appraisal of Soviet wheat breeding research capability.[121]

OUTLOOK FOR WHEAT VARIETY MODERNIZATION

Soviet goals for modernizing their wheat varieties were presented earlier.[97, 98] The Soviets also are considering growing feed wheats as well as food wheats in Siberia and in certain other areas. They expect feed wheat varieties, including some bred in the United States, to exceed yields of food wheat varieties by 15 to 20 percent. A feed wheat developed at Mironovka station was field tested in 1974. Reportedly, it contains less protein and gluten than wheat for human consumption but it is relatively high yielding. The Soviets are anticipating an export demand as well as a domestic need for high quality wheats. As a result strong and durum wheat varieties are to be selected for drought tolerance, disease resistance, lodge resistance and ability to respond to high doses of fertilizer to achieve maximum yields under normal rainfall. Drought tolerance, however, is regarded as a desirable but not a mandatory characteristic. An array of available varieties with different characteristics is expected to permit annual adjustments in the varieties to be grown for the best performance under the anticipated weather conditions. The greater yield potential of winter wheat is prompting the Soviets to extend winter wheat farther into the traditional spring wheat areas of the Volga and the New Lands regions of Siberia and Kazakhstan. Success will require varieties with winter hardiness of a different type than needed in the southern Ukraine. The Soviet goals suggest that 1) they are opting for maximum harvests in Siberia during favorable years in preference to stability of harvests over all years and 2) the national demand for quality food grains from Siberia is clearly conflicting with the local demand for feed grains.

In view of the opportunities that have been available to Soviet plant breeders, it is surprising that no major improvement in Soviet wheat varieties has been accomplished in the past two decades. The Soviets appear to have the capability to conduct wheat breeding research using valid procedures. They are aware of the serious shortcomings of Soviet wheat varieties and they have a clear mandate and support to correct these shortcomings. Soviet scientists recognize that the unique and varied environment conditions of the USSR will require them to develop their own varieties. Even though they may have recognized correct procedures, the mainstream of Soviet plant scientists has been handicapped in their training at the time when their skills were being developed. Other obstacles stem from the Soviet style of administering research, including the system of incentives to scientists which encourages the use of shortcut procedures to accelerate development of new varieties qualifying for zoned status.

Clearly the Soviets are challenged to emphasize a new direction in wheat breeding. The benefits from reconstructing and intensifying the breeding already found in the popular varieties probably have been exhausted, i.e. the best combinations obtainable by reshuffling the germ plasm in their popular varieties have largely been discovered. Now the Soviets must isolate and incorporate new germ plasm that intensely embodies the unique traits needed to overcome specific deficiencies. This particularly includes locating resistance to specific biotypes of leaf rust and of other pathogens rather than stressing the broad resistance of the old Russian varieties. Similarly, it probably means increased reliance on original dwarf germ plasm for the requisite degree of productivity and resistance to lodging. In essence, the scope and the coordination of the Soviet program must be broadened and vitalized.

Since there is little indication the Soviets have already begun such a fundamental change in wheat breeding, the lag in developing and introducing new and improved varieties may become still greater, because of the time required to breed, test, and commercialize new varieties. Moreover, succumbing further to stop-gap efforts rather than making real improvements would invite an even longer delay. At best the Soviets will not be able to make a major improvement in their commercial inventory of wheat varieties for at least several years and it may require a decade or more. While present Soviet wheat varieties possess some potential for responding to additional fertilizer and other improvements in agrotechnology, the rates of return from larger inputs will decline. Meanwhile, the vulnerability of current wheat varieties to conditions of stress, i.e. to adverse weather and particularly to epiphytotics, becomes an even more important restriction to yields and quality of production. In turn, the lack of modern varieties will be increasingly significant as a major cause of variation in Soviet wheat output. As in the past, the sharp variation in wheat output is likely to be generally reflected in Soviet imports of wheat, and other grains, contributing to wide fluctuations in international grain prices and aggravating the critical situation in the world grain supply.

APPENDIX A

BACKGROUND OF SOVIET WHEAT BREEDING RESEARCH

Contemporary wheat breeding was introduced into Russia at the turn of the century. The organization in 1894 of the Bureau for Applied Botany, now called the All-Union Scientific Research Institute for Plant Industry imeni Vavilov, is a historic milestone.[17, 18] N.I. Vavilov was a world pioneer in the collection of tens of thousands of various species, varieties and forms of agricultural crops, and established an effective program of plant breeding and field testing. Prior to World War II, Vavilov collected all of the significant foreign wheat germ plasm contained in the current Soviet wheat varieties. This collection has essentially been preserved. It now includes over 200,000 plants including 47,000 wheat varieties from 70 countries of both hemispheres. Some of the wheat germ plasm consists of species found only in the USSR.[18]

Prior to the mid-1930s, Soviet plant genetics and breeding research was of outstanding quality.[19, 20] During that period, Soviet biological and agricultural sciences were relatively free of ideological and political restrictions. From about 1935 on, Trofim D. Lysenko and his ambitious followers attacked genetics research and gradually infiltrated agricultural research institutions. For almost two decades Lysenkoism stifled biological and agricultural research so that the only real progress was, so to speak, illegitimate. Thousands of scientists in scientific institutions were dismissed or demoted. Many were arrested. Vavilov himself was arrested during a research trip in August 1940 and died in prison before the end of 1942.

Only after Stalin's death in 1953 did critics dare to attack Lysenko. Though he was removed in 1956 as president of the All-Union Academy of Agricultural Sciences, Lysenko's supporters continued to hold numerous responsible positions in research and teaching through the 1960s. The setbacks of Lysenkoism were real and severe, and persist today in many questionable plant breeding practices. It is the consensus of US scientists (agronomists and plant breeders) recently visiting with Soviet counterparts that overall Soviet genetics research is lagging considerably behind Western developments. To the credit of Soviet scientists, some outstanding crop breeding work was accomplished during the adverse political conditions and the lag is being overcome.

Wheat breeding work is presently carried out at 90 different experimental breeding stations and scientific research institutes located in the various geographic zones of the USSR.[21] But the development of most of the wheat varieties in commercial use, and particularly the predominant ones are attributed to a relatively few institutions.

The greatest advances in the development of spring wheat varieties and in overall wheat breeding research have been made at the Scientific Research Institute for the Agriculture of the Southeast.[22] Varieties from this station, including Saratovskaya-29, are widely used in the Volga region, the Urals, Siberia, and northern Kazakhstan. In 1970, varieties developed by this Institute were grown on 60 percent (about 28 million hectares) of the USSR spring wheat area. In 1972, 17 varieties from the Institute occupied 62 percent (27 million hectares) of all spring wheat plantings and such plantings reached 30 million hectares in 1974.

The most productive winter wheat breeding research has been done by the Krasnodar Scientific Research Institute for Agriculture (near Krasnodar in the North Caucasus) and Mironovskaya Scientific Research Institute for Wheat Breeding and Seed Raising (located near the village Mironovka about 110 miles southeast of Kiev).[23] In 1972, varieties from Krasnodar Institute occupied 48 percent of the total winter wheat area; most of the remaining area is devoted to Mironovka Station varieties. Other important winter wheat breeding centers are the All-Union Scientific Research Institute of Breeding and Genetics at Odessa and the Ukrainian Scientific Research Institute for Plant Raising, Breeding and Genetics imeni V. Ya. Yuriyev. Table 9 lists other Soviet wheat breeding institutions.

When wheat breeding institutions determine a new variety shows promise for commercial growing, they send it to the State Commission for Varietal Testing. The Commission continues testing the variety and decides whether to approve it for commercial growing in one or more designated regions. The Russian term indicating the Commission's approval, "rayonirovano," translates as "regionalized" sometimes as "regionized" or more conveniently as "zoned." The latter term is adopted for this report and compares to the US practice whereby state agricultural experiment stations, proceeding on the basis of comparative testing, "release" and "recommend" new varieties for commercial growing.

Table 9

USSR: Partial Listing of Wheat Breeding Research Institutions

All-Union Scientific Research Institute of Breeding and Genetics...	Odessa, Ukraine
Mironovskiy Scientific Research Institute of Wheat Breeding and Seed Raising	Mironovka, Ukraine (near Kiev)
Ukrainian Research Institute of Plant Protection...............	Kiev, Ukraine
All-Union Institute of Plant Industry imeni Nikolay I. Vavilov....	Leningrad, RSFSR
Krasnodar Scientific Research Institute for Agriculture...........	Krasnodar, RSFSR (Northern Caucasus)
Siberian Scientific Research Institute of Agriculture..............	Omsk, RSFSR (Western Siberia)
Ukrainian Scientific Research Institute for Plant Growing, Breeding and Genetics	Kharkov, Ukraine
Scientific Research Institute for Agriculture of the Southeast......	Saratov, RSFSR (Volga Region)

APPENDIX B

THE BEZOSTAYA-1 WHEAT VARIETY

The international pedigree of Bezostaya-1 is an excellent example of how an improved wheat variety might be structured from genetically diverse germ plasm brought together from geographically and ecologically remote origins.[66] [67] It is also an outstanding, albeit somewhat outdated, example of modern wheat breeding in the USSR.

Bezostaya-1 was zoned in 1959 but it is not clear when it was actually conceptualized and developed. Given the time required to breed and test a new variety, its development probably began before 1950. Recent Soviet reporting indicates a possibility that the variety may already have existed during World War II because "in 1942 the great wheatmaster Paval Panteleymonovich Luk'yanenko, of the Krasnodar Scientific Research Institute of Agriculture, took the "handful of grains" that was the ancestry of Bezostaya-1 with him to Kazakhstan when the Germans forced evacuation of the Kuban." The "handful of grains" may have been only one or more of the parent varieties used in the crossing. On the other hand, it could have been the final product, awaiting only to be discovered in nursery and field plot testing.

As Figure 2 shows, the parentage of Bezostaya-1 consists of varieties from about a dozen countries. One-half of the Bezostaya-1 pedigree is clearly of foreign origin, it was brought to the USSR in two varieties, one from Argentina and another from the US. Klein 33, an Argentine spring wheat, can be traced to the highly productive wheats of England and Holland. Its dwarf ancestor Akagomugi, a typical Japanese-Chinese dwarf coming from the Orient by way of an Italian wheat, contributed shortness and stiffness of straw needed for resistance to lodging under high yield conditions. The Italian (durum), Spanish, and Latin American genes likely contributed to quality of grain and hardiness. Klein-33 was collected by N. I. Vavilov prior to World War II and was a part of the variety collection "safeguarded by devoted scientists during the siege of Leningrad."[68]

The US input to Bezostaya-1 is the cross Kanred-Fulcaster- 266287.[69] The variety Fulcaster was developed in 1886 by a Maryland farmer who crossed the varieties Fultz and Lancaster, both stemming from the variety, Mediterranean. Mediterranean was brought to North America from some port in the Mediterranean in 1819 and a selection from it called Lancaster soon became widely grown in the soft winter wheat regions of the US. In 1862 the variety, Fultz, was found (selected) in a field of Lancaster by a Pennsylvania farmer. At one time Fulcaster was regarded in the US as disease resistent, high yielding and of good quality. The Kansas Experiment station fused Fulcaster with Kanred, a variety it had developed in 1917 as a selection from the old Russian variety Krymka (Crimean C.I. 1435), which in turn had been brought to the US in 1900. Kanred-Fulcaster 266287 was acquired as an F_6 generation by USDA in 1933. Thus, it was available to Vavilov so that he, rather than Luk'yanenko, may have bred Bezostaya-1.

The domestic half of the Bezostaya-1 pedigree is old Russian and East European germ plasm combining hardiness, adaptability and grain quality. The local Soviet winter wheat variety is not further identified. Vavilov, however, in 1936 described the Ukrainka variety as one of USSR's best winter types. Ukrainka is a Russian selection from Banat (Banatka), a variety imported from Hungary and Poland. The US Department of Agriculture introduced Banat into the US in 1900. Development of Ukrainka began in 1915 and was completed by 1924. Ukrainka was the first wheat variety developed at Mironovka Station, where Mivonovskaya-808 was later developed.[70] Prior to WW II Ukrainka was the USSR's most popular winter wheat variety, being grown on over 7 million hectares. High yielding for its time, it lacked resistance to winter kill, lodging, leaf rust and common bunt. It continued, however, to be widely grown during the 1930s and 1940s because efforts to create a more profitable variety for its region of adaptation were unsuccessful.

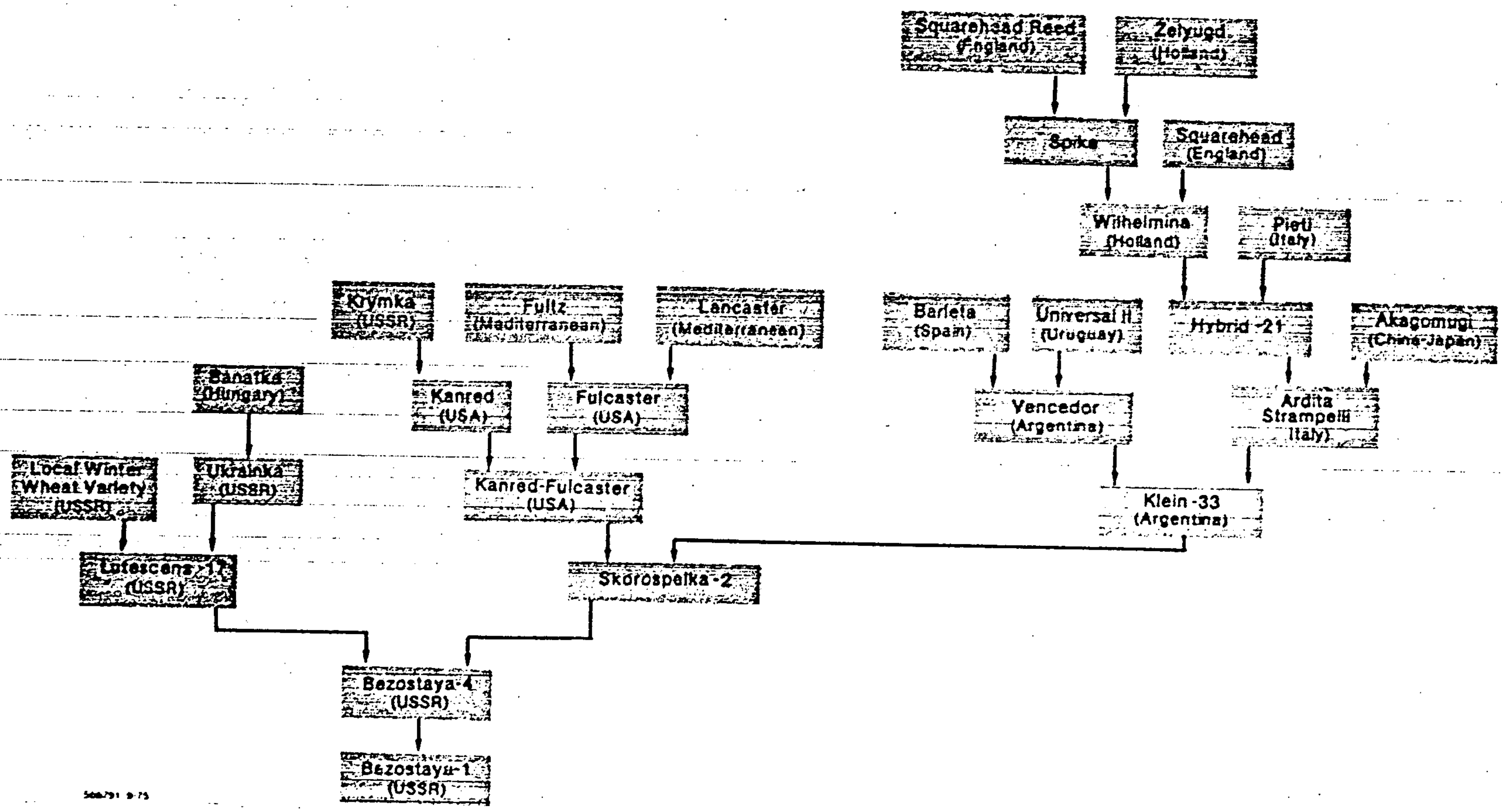

Figure 2. USSR: Parentage of the Wheat Variety Bezc staya-1

With such a diverse parentage it is not surprising that Bezostaya-1 performs fairly well under a wide range of conditions. But Bezostaya's shortfalls also can be traced to its ancestry. Insufficient winter hardiness may stem from Klein-33 being a spring wheat though some of the winter wheat ancestors were also bred for relatively mild climates. The dwarf germ plasm in Bezostaya-1 is rather dilute, which explains why Bezostaya-1 lodges under higher yield levels. Although Bezostaya-1 was once regarded as relatively disease resistant, it has not, even under heavy inbreeding, transmitted this trait to its progeny and its own resistance is breaking down with the buildup of new leaf rust strains.

APPENDIX C

THE MIRONOVKA WHEAT VARIETIES[70]

Wheat breeding research at Mironovka Station is of special interest because the Soviets claim Mironovskaya-808 was developed by changing a spring wheat into a winter wheat. The Soviets allege that they have special procedures that transform spring wheat varieties into winter wheat types and winter wheat varieties into spring types. Mironovka Station has a special laboratory for producing these transformations but similar research has been conducted at other Soviet locations. US wheat breeders generally scoff at the Soviet claims since there is no good theoretical basis for expecting success from their stated method. Apparently the Soviets also are not certain of its validity since it is effective on only certain populations of wheat. Other Soviet centers either have not attempted the Mironovka method or have found it ineffective.[70b] Breeding of winter wheat at Mironovka Station began in 1915; the variety Ukrainka used in breeding Bezostaya-1 was the first to be developed. Subsequently, conventional research at Mironovka was displaced by Lysenko procedures. At one time Lysenko ordered all self-pollinating plants be converted to a cross-pollination regime, thus ruining many pure strains of wheat held by research institutions and possibly affecting the very stock used at Mironovka. Other possible explanations of the Mironovka experience include natural outcrossing, mutations, cytoplasmic effect, plastid-mitochondria influences, trickery and wishful thinking. Lysenko formulated that wheat is either the spring or the winter type depending upon growing conditions when the plant is young. A recent Soviet explanation of what transforms spring wheats to winter type may be summarized as follows: Growing conditions in the fall, especially the type of light, play the main role in forming and strengthening the properties of wheat which define it as a winter type. When spring wheat is planted in the fall both its nourishment and its metabolism change. This change does not occur in a single step, and the creation of a new winter variety by this process may require up to 10 years.

Mironovka Station's first attempts at transformation began in the fall of 1949 with the seeding of five spring varieties: Lutescens-62, Narodnaya, Arnautka Nemerchanskaya, Kakhetinshaya Vetvistaya, and Artemovka. All were reportedly transformed and noted to be typical winter forms. Despite its popularity as a spring wheat, testing during 1951-1958 of the transformed Lutescens-62 failed to reveal a competitive variety. The first of the transformations to reach zoned status was Mironovskaya-246 obtained from Narodnaya, a spring durum wheat developed at the Ukrainian Institute. The new variety was selected in 1953, and turned over to the State Commission for Variety Testing of Agricultural Crops in 1957. In winter resistance it is not inferior to the most winter-hardy Ukrainian variety, Odesskaya-16. It was resistant to fungus diseases and quite resistant to Hessian fly and frit fly. First zoned in 1960, by 1965 Mironovskaya-264 was grown on almost 2 million hectares. Subsequently it was replaced by the superior yielding Mironovskaya-808 and is no longer grown.

In typical fashion, Mironovskaya-808 was developed from Artemovka spring wheat which was converted into winter wheat. Originally Artemovka was developed at Donets Oblast Station (Ukraine) as a selection from a spring wheat local to east-central Ukraine. The original Artemovka was planted in the fall (early winter) of 1950; selecting the best of the transformed plants began in 1953. Mironovskaya-808 was turned over to the State Testing Commission in 1957 but was not zoned until 1964. Subsequently its planted area increased rapidly. Many areas of the USSR are virtually totally dependent upon Mironovskaya-808 for all of their wheat crop. The northern countries of Eastern Europe also quickly adopted it. In Czechoslovakia, where it was zoned in 1966, it occupied 11.1 percent of the wheat area in 1967, 37.7 percent in 1968 and 61.7 percent in 1969. The GDR zoned this variety in 1968. Mironovskaya-808 is more winter hardy and of better milling and baking quality than Bezostaya-1. It has produced relatively high and stable yields under a wide range of soil and climatic conditions. Mironovskaya-808 performs better in the northern regions than it does in the south since it is more susceptible to lodging and to pests and diseases (including leaf rust) when planted in the south.

Mironovka scientists hoped to overcome Mironovskaya-808 shortcomings in another transformed variety, Kiyevskaya-893. Its origin is a Ukrainian spring wheat—one developed at Alma-Ata State Breeding Station as a transformation from the original Ukrainka winter wheat. Development of Kievskaya-893 began with the fall planting of spring type Ukrainka in 1955 and was completed in 1963. The Soviets claim it resists lodging and shattering, has high winter and drought resistance and is a strong wheat, but since it yields no more than Mironovskaya-808, it was never zoned.

The Soviets claim the transformation process has produced many lines which outyield Mironovskaya-808 (including some developed from India and Kenya spring wheats and from Saratovskaya-29) but none has been zoned. In 1965, 1233 altered lines were being studied. Instead Mironovka Station derived new, zoned varieties by using orthodox breeding procedures. Mironovskaya Yubileynaya-50 and Il'ichevka[71] are simply crosses of Mironovskaya-808 with Bezostaya-1. In actual procedure, Yubileynaya-50 was derived by crossing Lutescens-106 with Bezostaya-4. Development of Mironovskaya Yubileynaya-50, named in honor of the 50th Anniversary of Soviet power, began in 1959, when Bezostaya-1 was first zoned. It was turned over for state testing in 1966 and first zoned in 1969. Some reports rate Yubileynaya-50 as drought resistant, resistant to shattering, highly resistant to lodging and resistant to leaf rust and to damage by insects attacking the stem. Other discussions, however, describe it as highly susceptible to leaf rust. It is the first Soviet variety to yield over 100 quintals per hectare. It is listed among the strong wheats. It probably is more winter resistant than Bezostaya-1 and more lodge resistant than Mironovskaya-808.

Basically Il'ichevka is a duplicate of Yubileynaya-50 except the cross apparently was in reverse order, i.e. the male-female roles are switched. Allegedly, the offspring are markedly different. Development of Il'ichevka began in 1960; it was turned over for state testing in 1969 and named in commemoration of the centennial birthday of Vladimir Il'ichevich Lenin. Again, the reported list of desirable traits is long: resistant to lodging; high drought resistance; winter resistance as high as Mironovskaya-808; resistant to shattering; only slightly infected with leaf rust; high yielding under a range of conditions and extremely responsive to good fertility; and flour of strong quality. Il'ichevka was approved for growing on an expanded area in 1975 but Yubileynaya-50 was not listed with the latest selections.

APPENDIX D

SARATOVSKAYA AND OTHER IMPORTANT WHEAT VARIETIES

Wheat breeding research at the Scientific Research Institute of Agriculture of the Southeast began in 1911.[72 74] For 40 years, its spring wheat breeding program was headed by Professor Sleksey Pavlovich Shekhurdin, the first Soviet to develop new wheats by hybridization (i.e. by crossing). The hybridization research included the following types of crosses; intraspecific (different varieties of a given species, e.g. different common wheats); interspecific (different species, usually common and durum wheats); and intergeneric crosses (different genera; in this case, wheat with barley, couch grass and wheat grass). These followed Shekhurdin's discovery that many crosses may be necessary to unlock the full genetic potential of given parentage. The procedure he termed complex step hybridization introduces additional parentage or reintroduces the original parents in successive recrossings (backcrossing) in order to impart or accentuate desired characteristics. Although hybridization work began in 1912, the Institute's first improved varieties were obtained by methods akin to folk breeding by selecting plants from the ancient local varieties. Those qualifying for zoning include: Lutescens-62 (from Poltavka); Albidum-604; Erythrospermum-341; Gordeiform-432 (from Beloturka) and others. They are drought resistant and yielded 15 to 20 percent more than the old varieties. Of these, Lutescens-62 was exceptionally well adapted and zoned for practically all USSR regions—from Vologda in the North to Stavropol on the south and from Minsk in the west to Khabarovsk in the east. In 1938 it was planted on one-third of all spring wheat areas and in 1956, a year before Saratovskaya-29 was zoned, it still accounted for 25 percent of the area. By 1970 it was reduced to 1.5 million hectares (3.3 percent) having been largely replaced by Saratovskaya-29 in the main areas and by Diamant (from Sweden) and Apu (from Finland) in the northwest.

In 1912 the Saratov Institute began to cross the old Russian wheats Poltavka (common) and Beloturka (durum); this resulted in two sister varieties of common wheat being developed in 1927, Sarrubra and Sarroza. Of these, Sarrubra was zoned in 1931 and was widely planted through the mid-1960s, on as much as a million hectares. Sarroza, was an important ingredient in crosses of local varieties which created Saratovskaya-29 and several related varieties such as Albidum-43 and Saratovskaya-36,-38,-39, and -210. Later Sarrubra was combined with Saratovskaya-29 and other carriers of local ancient germ plasm to create Saratovskaya-42, a variety already developed in 1966 but only zoned in 1974 and now being given expanded zoning in 1975. As Figure 3 shows, Saratovskaya-42 and other recent varieties basically do not differ from Saratovskaya-29 being developed exclusively from old Russian varieties. Some Saratov Institute varieties were, however, developed with foreign germ plasm. For example, Lutescens-62 crossed with the Canadian variety Kitchener (a selection of Marquis) resulted in Lutescens-758 and Saratovskaya-33. These were developed in 1957 and zoned in 1963; in recent years they occupied almost 3 million hectares.

Shekhurdin and others at Saratov Institute were looking for drought resistance, rapid maturity and high yields along with grain qualities inherent in strong wheats. Their varieties also exceed the parentage in resistance to lodging, shattering and loose smut disease. The Saratov varieties have substantial shortcomings, the basic one being susceptibility to diseases: leaf and stem rusts, septoria leaf spot and root rot.[75] Varieties developed with rust resistance either did not yield enough or lost their resistance (e.g. Lutescens-758). The Soviets are attacking this problem, crossing the best Saratov varieties with the rust resistant semidwarf wheats from Mexico and the US, including the variety Selkirk. Several are now being state tested, including Saratovskaya-45 (Lutescens-1711).

Very few nationally important Soviet spring wheat varieties were developed outside of Saratov Institute. Bezenchukskaya-98 the second most important variety

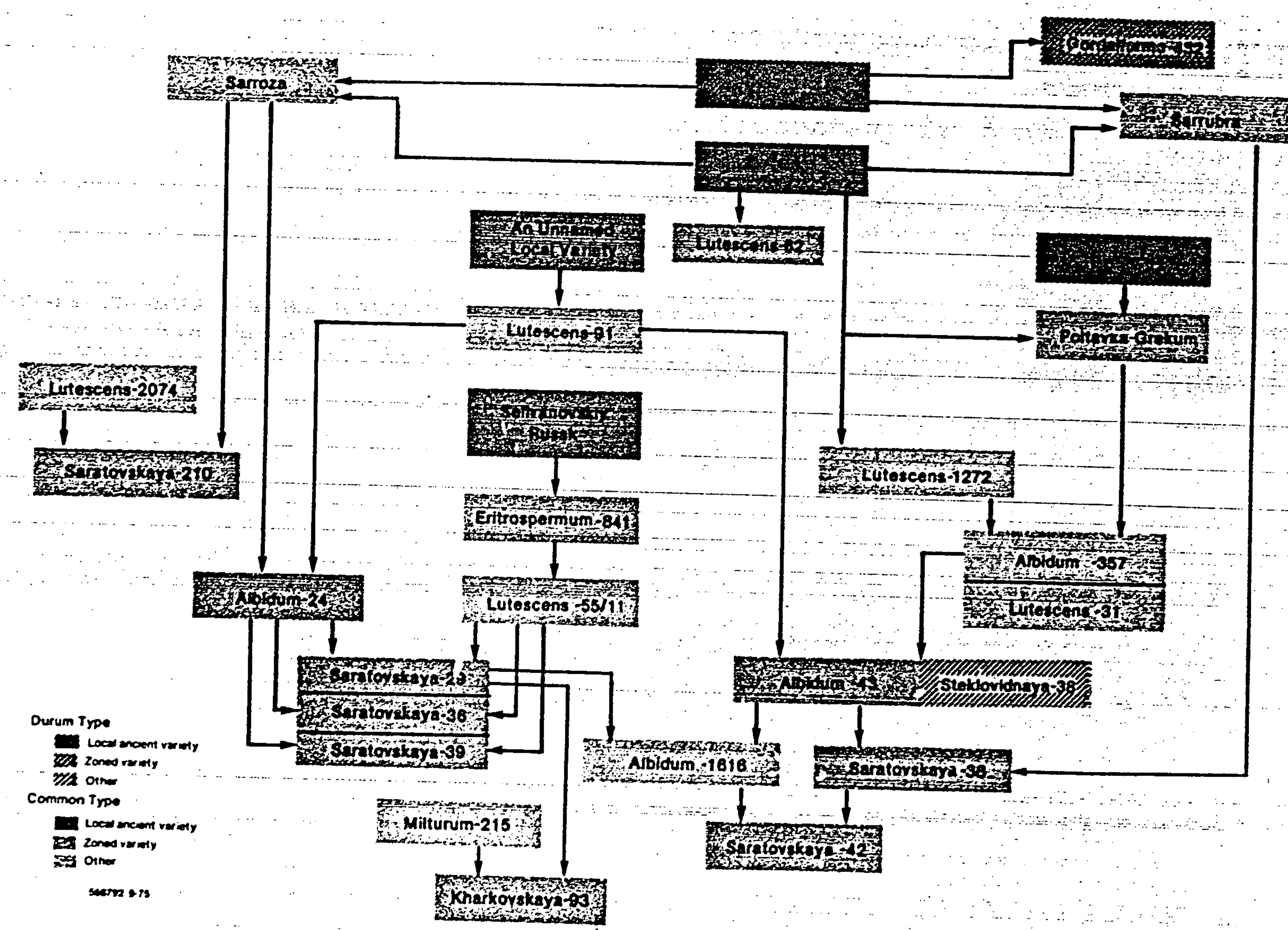

Figure 3. USSR: Parentage of Saratovskaya-29 and Related Spring Wheats

was developed at Kuybyshev Experimental Station and was zoned in 1951.[76] It stems from crossing the US variety Thatcher* with a selection from local varieties by the Bezenchukskaya Experimental Station. Kharkovskaya-46, which dominates the production of durum wheat, was developed by the Ukrainian Scientific Research Institute for Wheat Raising, Breeding and Genetics—far from the spring wheat belt where it produces its best quality grain.[77] Zoned in 1957, it is a cross between an Algerian variety and presumably an old Ukrainian variety.[79] Only two remaining varieties were planted on more than a million hectares in 1970, Skala from the Tulunsky Plant Breeding Section and Milturum-553 from the Saratov Institute.

*Thatcher is a US entry in the Vavilov collection and is labeled DS 11-21-44. Thatcher is noted for its stem rust resistance, stiff straw, quality and yield. It was bred at Minnesota Experiment Station in 1934 from the double cross Marquis-Iumillo and Kanred-Marquis. Iumillo is a durum variety. Marquis was developed in Canada as a cross of Red Fife (from Poland) and Hard Red Calcutta from India. Marquis is one of the greatest achievements in wheat breeding history. It formed the foundation of the hard red spring wheat industry in the US. The advantages of Marquis when it was developed were early maturity, enabling it to escape rust; high yields; and excellent quality of grain for milling and baking.

REFERENCES

The source references supporting this paper are identified in a list published separately. Copies of the list are available to authorized personnel and may be obtained from the originating office through regular channels. Requests for the list of references should include the publication number and date of this report.